STRATIGRAPHY AND PALAEOGEOGRAPHY OF THE YORKSHIRE OOLITES AND THEIR RELATIONSHIPS WITH THE LINCOLNSHIRE LIMESTONE

BY

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CONTENTS

SYNOPSIS

The Lincolnshire Limestone is correlated stratigraphically and on its ostracod fauna with the Hydraulic Limestone/Eller Beck Bed horizon and the Cave, Whitwell and Millepore Oolites and associated Upper Limestone and Yons Nab Beds of Yorkshire. The stratigraphy of these beds is discussed. The Hydraulic Limestone and the Eller Beck Bed are identified as facies variants of the same marine transgression correlated with the Lower Lincolnshire Limestone. The Cave, Whitwell and Millepore Oolites, the Upper Limestone and the Yons Nab Beds are correlated with the Upper Lincolnshire Limestone. The highest beds of the Upper Lincolnshire Limestone are older than the Grey Limestone Series of Yorkshire which is not represented in Lincolnshire. Eleven geological sections are described in detail and the palaeogeography of the marine horizons is discussed.

I INTRODUCTION

In previous publications (Bate 1963, 1963*a*, 1964) I have dealt with the ostracod faunas of the Lower Lincolnshire Limestone, the Cave Oolite and underlying marl and of the Whitwell and Millepore Oolites of Yorkshire. This study involved a stratigraphical investigation of the beds in question and it is now possible to show how the oolites, geographically isolated one from the other, were laid down contemporaneously in a shallow sea which covered north-eastern England at that time.

The dating of the Yorkshire and Lincolnshire Oolites is rather tenuous at the present time, and all that can be satisfactorily stated is that they are Bajocian, with part of the period of deposition taking place during *Hyperlioceras discites* times.

The purpose of the present paper is to give detailed sections, complete with the ostracod faunas found therein, and to use these faunas to correlate the Lincolnshire Limestone and the Yorkshire Oolites and at the same time to suggest the probable palaeogeography at that time.

In order to retain uniformity throughout related publications on the Middle Jurassic of north-eastern England I have retained the stratigraphical names used

FIG. 1. Map showing localities, sections and outcrop of the Lincolnshire Limestone south of the Humber, and of the correlated marine horizons in Yorkshire. Isolated outcrops in the north-central part of the map belong to the Eller Beck Bed.

previously. By international agreement the term Series is to be restricted to the primary division of a System. The units bearing this term here should not be so regarded.

The localities mentioned throughout the text are indicated in Text-fig. 1, whilst those which have supplied detailed geological sections are listed below with full map references.

1. Lincoln—Greetwell Quarry. Lower Lincolnshire Limestone consisting of the Blue and Silver Beds and the Kirton Cementstone Series, completely exposed. Map reference TF/002725.

2. Kirton Lindsey—Kirton Cement Quarry. Base of the Upper Lincolnshire Limestone, the Kirton Shale (*Acanthothiris crossi* Bed) completely exposed. Map reference SE/942011.

3. South Cave—Eastfield Quarry. Complete exposure of the Cave Oolite and, in 1947, of the underlying marl. Map reference SE/913323.

4. Kirkham—road cutting on the Firby Road. Hydraulic Limestone and underlying marl. Map reference SE/738658.

5. Whitwell—Seamer Lime and Stone Co. Quarry. Almost complete exposure of the Whitwell Oolite and sandy base of the Upper Limestone. Map reference SE/734672.

6. Crambeck—Stonecliff Wood. Top of Whitwell Oolite and almost complete exposure of the Upper Limestone. Map reference SE/737675.

7. Yons Nab headland—Cayton Bay. Complete foreshore section through the Millepore Oolite and Yons Nab Beds. Map reference TA/084844.

8. Cloughton. Complete foreshore section through the Millepore Oolite and Yons Nab Beds. Map reference TA/021958.

9. Hayburn. Complete foreshore section through the Eller Beck Bed. Map reference TA/017964.

10. Ravenscar. Complete cliff section through the Millepore Bed. Map reference NZ/981019.

11. Eller Beck. Almost complete stream section through the Eller Beck Bed. Map reference NZ/833023.

Acknowledgments. The contents of this paper have been based upon part of a Ph.D. thesis submitted to the University of Sheffield in 1961.

II STRATIGRAPHY

North Lincolnshire

The Lincolnshire Limestone

The Lincolnshire Limestone forms a thick lens of limestone striking north–south through Lincolnshire. The facies is variable and in parts (e.g. Ancaster) the limestone is quarried as a valuable building stone. Elsewhere (Kirton Lindsey) it is used in the manufacture of cement.

Although it is intended to make some reference to the Lincolnshire Limestone in the south of the county our main concern is with the outcrop in the north, around Lincoln and Kirton Lindsey. Evans (1952) has written an excellent account of the

BATHONIAN	Blisworth Clay	
	Great Oolite Limestone	
	Upper Estuarine Series	
BAJOCIAN	Upper Lincolnshire Limestone	Hibaldstow Oolite
		Acanthothiris crossi Bed
	Lower Lincolnshire Limestone	Kirton Cementstone Series
		Blue & Silver Beds
	Lower Estuarine Series	
	Northampton Sand	
LIAS	Upper Lias	

TABLE 1. Succession of Middle Jurassic strata in North Lincolnshire.

Lincolnshire Limestone of this region and this work should be consulted for more detailed information.

The succession in the Lincoln District is as follows (Table 1) :

The base of the Bathonian, the Upper Estuarine Series, overlies the Upper Lincolnshire Limestone unconformably, and so far as the ostracod faunas are concerned bears no relationship to the limestone beneath. A description of the Upper Estuarine Series ostracods is now in the press.

The Lincolnshire Limestone is divisible into Upper and Lower with further subdivisions (in the north) into the Hibaldstow Oolite, the *Acanthothiris crossi* Bed, the Kirton Cementstone Series and the Blue and Silver Beds. Towards the south of Lincolnshire the name Hibaldstow Oolite is changed to the Ancaster Beds. The Lincolnshire Limestone itself lies unconformably on the Lower Estuarine Series beneath. This Series tends to be composed of unfossiliferous sands and clays with occasional plant remains.

According to Swinnerton & Kent (1949) towards the centre of the Lincolnshire Basin the Lincolnshire Limestone is most complete, the highest beds being restricted to the Great Ponton–Ropsley area. The Great Ponton *Terebratula* Beds are the youngest of all. Apart from the *A. crossi* Bed at the base, the Upper Lincolnshire Limestone has generally yielded only a poor ostracod fauna and no detailed sections are given. The ostracods obtained from samples of the uppermost Upper Lincolnshire Limestone are identical with those present lower down. For example the fauna obtained from a large overgrown quarry at Braceby (map reference TF/009351) included the following : *Praeschuleridea subtrigona subtrigona* (Jones & Sherborn), *Aulacocythere punctata* Bate, *Eocytheridea carinata* Bate, *Bairdia hilda* (Jones), *Ektyphocythere triangula* (Brand), *Fuhrbergiella* (*Praefuhrbergiella*) *arens* Bate, *Systenocythere exilofasciata* Bate, *Cytherelloidea catenulata* (Jones & Sherborn) *Pleurocythere kirtonensis* Bate, *Dolocythere maculosa* Bate, *Micropneumatocythere globosa* Bate, *Southcavea reticulata* Bate, *Monoceratina vulsa* (Jones & Sherborn), *Paracypris bajociana* Bate, and *Glyptocythere* sp. Of this fauna only *Glyptocythere*

sp. is not present also in the Lower Lincolnshire Limestone, being confined to the highest beds of the Upper Lincolnshire Limestone. This is possibly the lowest occurrence (stratigraphically) of the genus, more typically developed in Yorkshire within the Grey Limestone Series.

The base of the Upper Lincolnshire Limestone is represented by the *A. crossi* Bed which forms a prominent marker across Lincolnshire. In the north at Kirton Lindsey the 14 feet of strata known as the Kirton Shale contain the brachiopod *Acanthothiris crossi* and are regarded here as the lateral equivalent of a much harder limestone bed further south.

The Kirton Cementstone Series of the Lower Lincolnshire Limestone consists of poorly oolitic, rather chalky limestones with marl bands interbedded. The Blue and Silver Beds, on the other hand, tend to be rather more massively bedded and in some cases strongly oolitic. The Lincolnshire Limestone as a whole extends northwards as far as the Humber and is represented on the north bank by the Cave Oolite. Arkell (1933 : 215) correlates this with the Hibaldstow Oolite of Lincolnshire and points out that in a boring at Brantingham the beds below the Cave Oolite are of similar facies to the Kirton Beds. A stratigraphical correlation is therefore possible across the Humber. A few miles further north at South Cave the marine marls below the Cave Oolite were exposed in 1947 in a sump put down in Eastfield Quarry, but as will be seen later do not contain an ostracod fauna completely identical with the Kirton Beds south of the Humber, a number of locally restricted species being present.

South Yorkshire

The Cave Oolite is a shelly oolitic limestone with sand intercalations overlain by approximately 12 feet of sand known as the Upper Estuarine Series. It is doubtful, however, if these sands are of estuarine origin. At the base of the Cave Oolite the brachiopod *Acanthothiris broughensis* Muir-Wood (1952 : 123) is recorded and together with the record of *Acanthothiris crossi* s.l. from the Whitwell Oolite further north has been used to correlate the Whitwell, Cave and Hibaldstow Oolites (Kent, 1955 : 208).

Below the Cave Oolite the marl sequence developed in the region of South Cave forms part of the Basement Beds (Fox-Strangways, 1892 : 176), a name now restricted to the marl beds alone (Neale, 1958 : 164). These marine marls, from 4–6 ft. in thickness, are no longer exposed. The Basement Beds overlie a thin porcellanous limestone known as the Hydraulic Limestone, and Fox-Strangways (1892 : 176) recorded the thickness of this bed in the Market Weighton District as 2 ft. 6 ins. At the present time it does not appear in section, only as fragments on the surface. At Ellerker (map reference SE/927297) a small ostracod fauna comprising the following has been obtained from this bed : *Paracypris bajociana* Bate, *Progonocythere cristata* Bate and *Ektyphocythere triangula* (Brand).

The Lower Estuarine Series, although no longer exposed around Market Weighton (not sampled), is reported to consist of clays and yellow sandy shales with plant remains, shells and crustaceans (Neale 1958 : 164).

The Cave Oolite and the underlying beds extend from the Humber to Market Weighton where they pass beneath the overstepping Chalk.

Much has been written concerning the geological implications of the break in outcrop which occurs at Market Weighton, admirably reviewed by Kent (1955). The ideas put forward have varied from Fox-Strangways' interpretation (1892) that the Market Weighton area was a land barrier extending from the west, to that of Kendall's (1905) that it was an anticlinal feature, a continuation of the Wharfe Axis. Kent's interpretation (1955) was that the Market Weighton area was more in the nature of a broad non-subsiding rigid block.

Jurassic sediments from Rhaetic times onwards were affected by the structure and thin appreciably towards it from both north and south. During the period of deposition with which we are concerned in this paper, it is doubtful whether there was continuous deposition over the structure north–south but rather continuation was effected around the structure to the east. The interpretation that the Market Weighton area was a stable region during Middle Jurassic times, acting as a partial land barrier, is accepted here.

North-East Yorkshire

Hydraulic Limestone/Eller Beck Bed

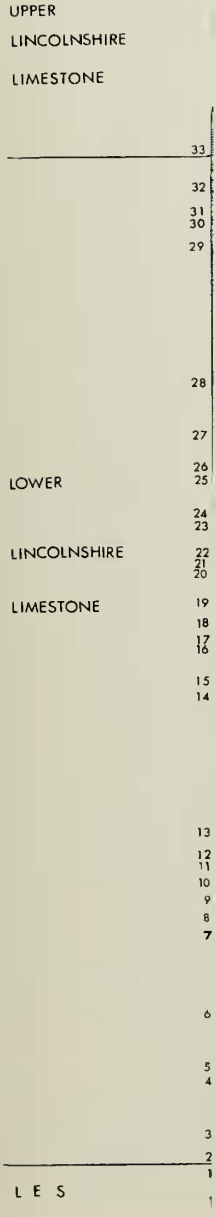
$5\frac{1}{2}$ miles north of Market Weighton the Middle Jurassic sediments reappear at Millington and again at Great Givendale, but are only continuous at outcrop from Kirkby Underdale, $3\frac{1}{2}$ miles farther north.

The succession of beds in this part of the Jurassic outcrop is indicated in Table 2. At the base there is a marine sandstone known as the Dogger. This bed does not

STAGE	SOUTH	N.E. INLAND	N.E. COASTAL	N.E CENTRAL
CALLOVIAN	Upper Estuarine Series	Cornbrash?	Cornbrash	Cornbrash
BATHONIAN		Upper Deltaic Series	Upper Deltaic Series	Upper Deltaic Series
		Grey Limestone Series	Grey Limestone Series	Grey Limestone Series
		Middle Deltaic Series (Upper)	Middle Deltaic Series (Upper)	Middle Deltaic Series
BAJOCIAN	Cave Oolite	Upper Limestone	Yons Nab Beds	
		Whitwell Oolite	Millepore Oolite	
	Basement Beds	Middle Deltaic Series (Lower)	Middle Deltaic Series (Lower)	
	Hydraulic Limestone	Eller Beck Bed / Hydraulic Limestone	Eller Beck Bed / Hydraulic Limestone	Eller Beck Bed
	Lower Estuarine Series	Lower Deltaic Series	Lower Deltaic Series	Lower Deltaic Series
		Dogger	Dogger	Dogger
TOARCIAN	Lias	Lias	Lias	Lias

TABLE 2. Succession of Middle Jurassic strata in Yorkshire.

SOUTH


UPPER
LINCOLNSHIRE
LIMESTONE
33
32
31
30
29
28
27
26
25
LOWER
24
23
LINCOLNSHIRE
22
21
20
LIMESTONE
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
L E S
1

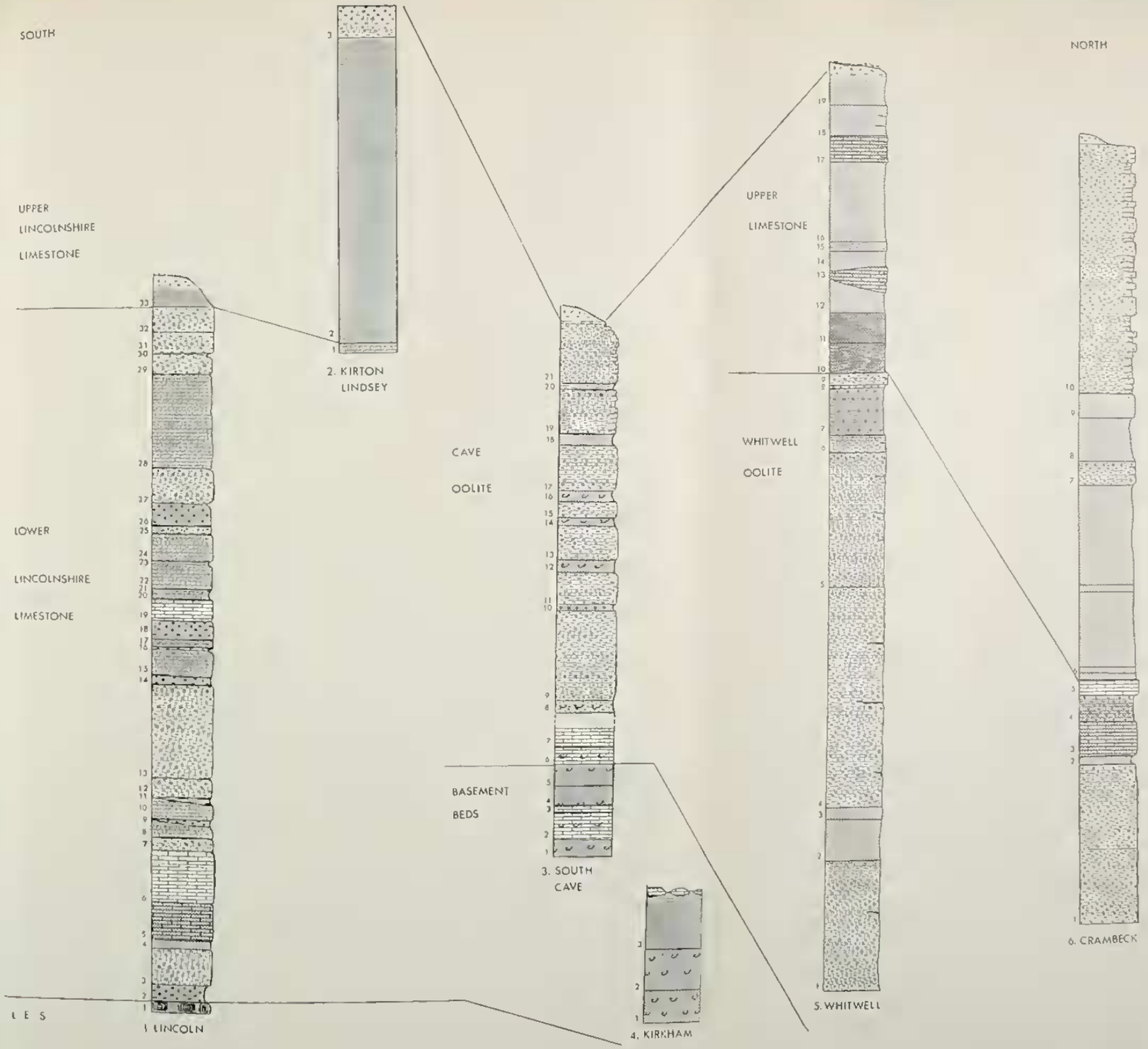


FIG. 2 Sections 1–6.

appear to be developed south of Acklam, but as it is of no particular importance here will not be dealt with further.

Overlying the Dogger is the first evidence of the northern delta, the Lower Deltaic Series. This deltaic sequence is the first of three major deltaic episodes which interfinger with marine incursions entering from the east and south-east. The source of the deltaic sediments lies to the north of the Yorkshire Basin. The Lower Deltaic Series varies in thickness from about 50 ft. at Acklam in the south-west to as much as 160 ft. in the north.

Above the Lower Deltaic Series comes the first marine episode, represented by the Hydraulic Limestone, in lithology exactly the same as in the South Cave area. Outcrops are rare and for the most part the course of the limestone is traced only on a break in land slope and by fragments which commonly occur at the surface. The only outcrop encountered here was at Kirkham (section No. 4), although loose debris from an early working on the hillside behind Castle Howard Station, map reference SE/737668, provided a good source.

The Hydraulic Limestone is found at the surface only along the western flanks of the Yorkshire Basin (the centre being obscured by Alluvium of the Vale of Pickering). In the east it probably occurs out to sea but has been found in the Fordon borehole (Falcon & Kent 1960 : 27, where it was incorrectly named the Ellerbeck Bed) as a 4 ft. bed of cementstone. In the west the Hydraulic Limestone facies is recognizable as far north as Skipton Hill on the western flanks of the Hambleton Hills. To the north of this region a marine horizon is recognizable, represented by a thick, ripple-marked sandstone with associated fossiliferous ironstone bands, known under the single name of Eller Beck Bed, after the type locality on the Eller Beck (section No. 11). This facies is found over the whole of the north–central outcrop of the Middle Jurassic and in the coastal exposures to the east, where a good section was measured close to Hayburn Wyke (section No. 9). The Eller Beck Bed facies outcrops to the south of Hayburn but does not extend as far south as Cloughton, the outcrop striking out to sea. The Hydraulic Limestone facies correlated with the Eller Beck Bed by Fox-Strangways (1892 : 194, pl. 4) almost certainly comes in again (out to sea) a few miles south of Cloughton.

The Millepore/Whitwell Oolite

One of the more important marine horizons in the Yorkshire Basin is that represented by oolitic sediments known locally in the east as the Millepore Oolite and in the west as the Whitwell Oolite. Although geographically isolated these beds have long been correlated (Wright 1860 : 32 ; Fox-Strangways 1892 : 206). The Millepore/Whitwell Oolite horizon is separated from the Hydraulic Limestone/Eller Beck Bed horizon below by deltaic sediments of the Lower Middle Deltaic Series and overlain by sediments of the Upper Middle Deltaic Series. As the oolitic horizon does not, in fact, extend all over the northern part of the Basin, in that part the Upper and Lower Middle Deltaic Series are not identifiable as separate units.

In the east the Millepore Oolite first appears at outcrop in Gristhorpe Bay with the best section exposed at Yons Nab headland (section No. 7). The Millepore Oolite is, however, present at depth in the Fordon borehole (Falcon & Kent 1960), where

57 ft. of oolite and sandstone is recorded. At Yons Nab the Millepore Oolite is represented by 15 ft. of false-bedded oolite and overlain by 25 ft. of marine sandstone and shale known as the Yons Nab Beds, a name first introduced by Sylvester-Bradley (1953 : 37). These contain a rich shallow water lamellibranch fauna as well as plentiful ostracods and plant remains. The Millepore Oolite is well developed at Osgodby Nab, the northern headland of Cayton Bay, but is there overlain by 20–30 ft. of deltaic sandstone and not by the Yons Nab Beds. This sandstone probably represents a contemporaneous deltaic distributary (Bate 1959 : 163). At Cloughton Wyke, seven miles to the north, a reduced thickness of the Millepore Oolite (10 ft. 1 in.) is overlain by 7 ft. 6 ins. of arenaceous shale and sandstone containing marine fossils. This upper marine horizon, equivalent to the Yons Nab Beds, can be seen to pass laterally into a typical deltaic sandstone only a few hundred yards from the section. The Millepore Oolite similarly passes laterally northwards into a pure sandstone facies which at Ravenscar (section No. 10) still contains casts of marine fossils, e.g. "*Trigonia*" sp. Farther north it is impossible to distinguish this horizon from the deltaic sandstones of the region.

Along the western outcrop of the Middle Jurassic the oolitic facies is known as the Whitwell Oolite after its development at Whitwell (section No. 5). The rock is a coarse-grained oolite here often massively bedded and developing some clay beds towards the top. Some 33 ft. 9 ins. of sediment belonging to the Whitwell Oolite can be seen, together with 11 ft. 9 ins. of sand and sandy oolite which occur above. At Crambeck (section No. 6), $\frac{1}{2}$ mile to the east, only the upper part of the Whitwell Oolite is exposed together with a more complete development of the overlying beds which consist of 12 ft. of sand and sandstone, a 1 ft. limestone bed and 11–12 ft. of flaggy oolite, the latter termed the Upper Limestone by Hudleston (1873 : 327) and retained here to incorporate the limestone and the underlying sands. The Upper Limestone is a localized upper division of the Whitwell Oolite comparable to the Yons Nab Beds in the east, and may be traced northwards for a distance of about 10 miles and southwards for about 2 miles from the Whitwell Quarries. From Burythorpe the Whitwell Oolite may be traced to Kirkby Underdale as a continuous outcrop and as an isolated outlier at Great Givendale. Although the Millepore Oolite in the east thickens to the south (see Fordon borehole) the Whitwell Oolite appears to thin onto the Market Weighton structure.

Like the Millepore Oolite the Whitwell Oolite, when traced northwards, becomes progressively more sandy until at Kirkby Knowle it is nothing more than a false-bedded coarse-grained sandstone identified more on its position in relation to other beds than on its fossil content.

The stratigraphy and palaeogeography of the other important marine horizon of the Yorkshire Middle Jurassic, the Grey Limestone Series, have been dealt with elsewhere (Bate 1965).

III STRATIGRAPHICAL SECTIONS

All the ostracods listed below have been described by Bate (1963, 1963*a*, 1964) and are represented in the collections of the Department of Palaeontology, British Museum (Natural History).

Section No. 1. Lower Lincolnshire Limestone (Text-fig. 2), complete section in Greetwell Quarry, Lincoln, of the Blue and Silver Beds and of the Kirton Cementstone Series.

Kirton Cementstone Series

	ft.	*in.*
33. Soft grey marl passing upwards into subsoil. Ostracods abundant: *Bairdia hilda, Progonocythere cristata, Ektyphocythere triangula, Cytherella fullonica* and *Praeschuleridea subtrigona subtrigona* seen to	1	0
32. Massive grey oolitic limestone	1	3
31. Coarse white oolite with abundant shells	1	2
30. Yellow marl with ooliths. Ostracods: *Aulacocythere punctata, Cytheromorpha ? greetwellensis, Progonocythere cristata, Systenocythere exilofasciata, Dolocythere maculosa, Praeschuleridea subtrigona subtrigona, Fuhrbergiella* (*Praefuhrbergiella*) *arens* and *Ektyphocythere triangula*	0	1
29. Coarse white oolite. Ostracods: *Aulacocythere punctata, Systenocythere exilofasciata, Pneumatocythere carinata, Dolocythere maculosa, Bairdia hilda* and *Praeschuleridea subtrigona subtrigona* .	1	0
28. Coarse rubbly oolite. Ostracods: *Fuhrbergiella* (*P.*) *arens, Systenocythere exilofasciata, Pneumatocythere carinata, Micropneumatocythere convexa, Southcavea reticulata, Asciocythere lacunosa, Dolocythere maculosa* and *Praeschuleridea subtrigona subtrigona*	4	6
27. Shelly blue-hearted oolite. Corals and horizontal burrows . .	1	9
26. Grey oolitic shale with wedges of marl. Ostracods: *Dolocythere maculosa, Pneumatocythere bajociana, Acanthocythere* (*Protoacanthocythere*) *faveolata, Micropneumatocythere convexa, Systenocythere exilofasciata, Aulacocythere punctata* and *Praeschuleridea subtrigona subtrigona*	1	3–10
25. Coarse shelly oolite with fragments of marlstone. Ostracods: *Ektyphocythere triangula, Asciocythere lacunosa, Monoceratina vulsa, Eocytheridea faveolata, E. reticulata* & *E. lacunosa, Micropneumatocythere globosa* & *M. convexa, Aulacocythere punctata, Dolocythere maculosa, Systenocythere exilofasciata, Pneumatocythere bajociana, Camptocythere lincolnensis, Cytheropterina comica* & *C. gravis, Praeschuleridea subtrigona subtrigona* and *P. ventriosa* .	0	8
24. White marlstone. Ostracods rare: *Pneumatocythere bajociana* and *Praeschuleridea subtrigona subtrigona*	1	8
23. Chocolate-brown marl, weathering grey. Ostracods rare: *Pneumatocythere bajociana* and *Micropneumatocythere globosa* . .	0	2
22. White marlstone. Ostracods rare: *Praeschuleridea subtrigona subtrigona* + indet. species	1	2

	ft.	in.
21. Chocolate-brown, weathering grey marl. Ostracods rare: *Pneumatocythere bajociana* and *Dolocythere maculosa*	0	2
20. Rubbly white marl with scattered ooliths. Ostracods common: *Praeschuleridea subtrigona subtrigona, Pneumatocythere bajociana, Micropneumatocythere globosa, Dolocythere maculosa, Systenocythere exilofasciata, Cytheropterina comica, Ektyphocythere triangula, Cytherelloidea catenulata, Paracypris bajociana, Monoceratina vulsa* and *Acanthocythere* (*P.*) *faveolata*	0	5
19. Blue-hearted fine-grained limestone weathering cream. *Nerinea* and lamellibranch shells common. Scattered ooliths. Ostracods rare: *Micropneumatocythere convexa* and *Cytherelloidea catenulata*	1	2
18. Grey marl with scattered ooliths and marlstone fragments. Ostracods: *Dolocythere maculosa, Pneumatocythere bajociana, Ektyphocythere triangula* and *Praeschuleridea subtrigona subtrigona*.	0	9
17. White marlstone with abundant ostracods: *Praeschuleridea subtrigona subtrigona* & *P. ventriosa, Ektyphocythere triangula, Cytheropterina comica* & *C. gravis, Pneumatocythere bajociana, Acanthocythere* (*P.*) *faveolata, Systenocythere exilofasciata, Dolocythere maculosa, Micropneumatocythere globosa* and *Cytherelloidea eastfieldensis*	0	8
16. Oolitic marl. Ostracods: *Pneumatocythere bajociana, Praeschuleridea subtrigona subtrigona, Dolocythere maculosa, Systenocythere exilofasciata, Cytheropterina comica* and *Micropneumatocythere globosa*	0	1
15. White marlstone with scattered ooliths. Ostracods: *Platella jurassica, Cytheropterina gravis, Acanthocythere* (*P.*) *faveolata, Eocytheridea faveolata, Micropneumatocythere globosa, Ektyphocythere triangula, Cytherelloidea catenulata, Systenocythere exilofasciata* and *Praeschuleridea subtrigona subtrigona*	1	7
14. Shaly oolitic marl. Ostracods: *Systenocythere exilofasciata, Pneumatocythere bajociana, Camptocythere lincolnensis, Cytheropterina gravis, Micropneumatocythere globosa* and *Dolocythere maculosa*	0	3

Blue and Silver Beds

13. Cream limestone with scattered ooliths, passing laterally into more coarsely oolitic limestone. In part also a shelly limestone. Ostracods not common: *Micropneumatocythere globosa, Cytherelloidea catenulata* and *Praeschuleridea subtrigona subtrigona*.	4	9
12. Fine grained limestone with scattered ooliths	0	11
11. Sandy shale—no microfauna	0	0–2

	ft.	in.
10. Cream marlstone with shells and scattered ooliths. Ostracods: *Cytheropterina comica* & *C. gravis*, *Systenocythere exilofasciata*, *Praeschuleridea subtrigona subtrigona*, *Cytherella fullonica*, *Camptocythere lincolnensis*, *Pneumatocythere bajociana*, *Fuhrbergiella* (*P.*) *arens* and *Bairdia hilda*	0	9
9. Brown clay with ooliths. Ostracods rare: *Systenocythere exilofasciata*, *Camptocythere lincolnensis*, *Pneumatocythere bajociana*, *Fuhrbergiella* (*P.*) *arens*, *Cytherella fullonica*, *Cytherelloidea catenulata*, *Cytheropterina comica*, *Ektyphocythere triangula* and *Dolocythere maculosa*	0	1–4
8. Cream marly bed with scattered ooliths. Ostracods: *Praeschuleridea subtrigona subtrigona*, *Dolocythere maculosa* and *Systenocythere exilofasciata*	0	6
7. Coarse, cream oolite with reddish colour banding and vertical pipes. Ostracods: *Cytheropterina gravis* and *Praeschuleridea subtrigona subtrigona*	0	6
6. Blue hearted fine grained limestone with cream weathering surface. Ooliths and shell fragments present throughout. Ostracods: *Systenocythere exilofasciata*, *Cytheropterina gravis* and indet. species	2	6
5. Sandy limestone with coarse ooliths	1	8
4. Fine grained, ochre coloured sandstone	0	5
3. Ferruginous oolite	1	8
Lower Estuarine Series		
2. Grey-green oolitic clay	0	10
Northampton Sand Ironstone		
1. Oolitic ironstone with Boxstones and concretions. seen to	0	6

Section No. 2. Complete section through the Kirton Shale, Kirton Cement Quarry, Kirton Lindsey (Text-fig. 2).

	ft.	in.
3. Base of Hibaldstow Oolite.		
2. Kirton Shale. Black clay, becoming brownish-buff in upper 3 feet. Ostracods extremely abundant: *Acanthocythere* (*P.*) *faveolata*, *Aulacocythere punctata* & *A. reticulata*, *Dolocythere maculosa*, *Bairdia hilda*, *Monoceratina vulsa* & *M.* cf. *scrobiculata*, *Ektyphocythere triangula*, *Praeschuleridea subtrigona subtrigona*, *Paracypris bajociana*, *Progonocythere cristata*, *Kirtonella plicata*, *Cytherella fullonica*, *Cytheromorpha* ? *greetwellensis*, *Cytherelloidea catenulata*, *Platella jurassica*, *Pleurocythere kirtonensis* & *P. nodosa* and *Fuhrbergiella* (*P.*) *arens*	14	0
1. Top of Kirton Cementstone Series.		

Section No. 3. Cave Oolite, Eastfield Quarry, South Cave, Yorkshire. Almost complete section through the Cave Oolite and (in 1947) partial section through the underlying marls (Text-fig. 2).

	ft.	in.
Cave Oolite		
21. Flaggy oolite, rather coarse grained and compact. Shell fragments, no ostracods . . . . . seen to	3	0
20. Sandy marl	0	3
19. Cream, sandy, oolitic limestone, flaggy with shells and plant remains. Ostracods present but poorly preserved and indeterminate	2	3
18. Yellow-brown sandy marl with cream oolitic marlstone band. Ostracods present in both lithologies: *Ektyphocythere triangula, Aulacocythere punctata, Micropneumatocythere globosa, Systenocythere exilofasciata, Fuhrbergiella* (*P.*) *arens, Eocytheridea elongata, Praeschuleridea subtrigona subtrigona, Southcavea reticulata* and *S. bajociana*	0	7
17. Fine grained creamy limestone, oolitic	2	3
16. Shell sand with purple marly parting at top. Ostracods: *Micropneumatocythere convexa, M. globosa, Aulacocythere punctata, Praeschuleridea subtrigona subtrigona, Systenocythere exilofasciata, Southcavea reticulata* and *S. grandis*	0	3–5
15. Shelly oolite. Ostracods: *Eocytheridea ? astricta, Praeschuleridea subtrigona subtrigona, Dolocythere maculosa, Fuhrbergiella* (*P.*) *arens, Pleurocythere nodosa, Micropneumatocythere convexa, Aulacocythere punctata, Southcavea bajociana, S. reticulata, Asciocythere lacunosa* and *A. acuminata*	0	11
14. Shell sand with purple marly partings at top. Ostracods: *Aulacocythere punctata, Southcavea reticulata, Micropneumatocythere convexa, Praeschuleridea subtrigona subtrigona, Pneumatocythere carinata, Ektyphocythere triangula, Fuhrbergiella* (*P.*) *arens* and *Dolocythere maculosa*	0	7
13. Blue hearted creamy limestone. Shelly and in part oolitic . .	1	9
12. Ochre coloured shell sand with *Pentacrinus* ossicles, echinoid spines and shell fragments. Ostracods: *Pneumatocythere carinata, ?Pneumatocythere bajociana, Praeschuleridea subtrigona magna, Aulacocythere punctata, Fuhrbergiella* (*P.*) *arens, Southcavea reticulata, S. grandis, Eocytheridea carinata, E. elongata, Asciocythere lacunosa, Dolocythere maculosa, Systenocythere exilofasciata, Ektyphocythere triangula* and *Acanthocythere* (*P.*) *faveolata*	0	8
11. Blue hearted, coarsely oolitic limestone. Ostracods: *Dolocythere maculosa* and *Praeschuleridea subtrigona magna* . . .	1	8

	ft.	in.
10. Creamy-yellow, oolitic limestone, very fossiliferous and crowded with *Pentacrinus* ossicles. Ostracods: *Asciocythere lacunosa, Praeschuleridea subtrigona magna, Southcavea bajociana, S. grandis, S. reticulata, Cytherelloidea catenulata, Pleurocythere nodosa, Ektyphocythere triangula, Paracypris bajociana, Systenocythere exilofasciata, Bairdia hilda, Micropneumatocythere convexa, Dolocythere maculosa, Fuhrbergiella (P.) arens, Eocytheridea ? astricta, E. elongata* and *E. carinata*	0	3
9. Coarsely oolitic cream oolite. Ostracods: *Monoceratina vulsa, Praeschuleridea subtrigona subtrigona, Paracypris bajociana* and indeterminate ostracods	4	8
8. Shelly, coarsely oolitic limestone. Ostracods: *Southcavea bajociana & S. reticulata, Eocytheridea carinata & E. faveolata, Aulacocythere punctata, Micropneumatocythere globosa, M. convexa, Paracypris bajociana, Ektyphocythere triangula, Fuhrbergiella (P.) arens, Asciocythere acuminata, Praeschuleridea subtrigona subtrigona, Systenocythere exilofasciata, Dolocythere maculosa, Acanthocythere (P.) faveolata* and *Pneumatocythere carinata*	0	9
Base of Cave Oolite section as seen in Eastfield Quarry. Section continued in sump excavated in 1947. Details of section from Professor P. C. Sylvester-Bradley.		

Basement Beds

7. Rubbly pellety limestone with lamellibranchs . . seen to	0	10
6. Ferruginous limestone full of shells	0	11
5. Ferruginous marl full of lamellibranchs and crinoid stems. This marl has been dumped by the side of the sump and has provided the following ostracod fauna: *Cytherelloidea eastfieldensis, Paracypris bajociana, Progonocythere reticulata, Monoceratina vulsa, Acanthocythere (P.) faveolata, Aulacocythere punctata, Micropneumatocythere convexa, Pneumatocythere bajociana, Pleurocythere kirtonensis, Pleurocythere* sp., *Dolocythere maculosa, Homocytheridea cylindrica, Tetracytheridea punctata, Asciocythere lacunosa, Eocytheridea elongata, E. lacunosa, E. ? astricta, E. ? erugata, Paraschuleridea ornata, Paraschuleridea* sp., *Praeschuleridea ventriosa, Cytheropterina comica, C. gravis, Ektyphocythere triangula, Southcavea bajociana* and *Systenocythere exilofasciata* .	1	2
4. Shale, shelly at base, marlstone impersistant at top . . .	1	2
3. Nodular limestone with lamellibranchs	0	2–3
2. Grey limestone full of gastropods and crushed lamellibranchs .	1	4
1. Shelly shale. Ostracods: *Progonocythere reticulata, Eocytheridea lacunosa, Praeschuleridea ventriosa, Asciocythere lacunosa, A. acuminata, Cytheropterina comica, Micropneumatocythere convexa,*		

	ft.	in.
Pneumatocythere bajociana, Dolocythere maculosa and *Ektyphocythere triangula* . . . . . seen to	1	0

Section No. 4. Hydraulic Limestone and associated marls exposed in a road cutting at Kirkham. The Firby Road section (Text-fig. 2). These sediments come below the marine succession exposed in the Eastfield Quarry, South Cave, and occur to the north of the Market Weighton structure.

4. Hydraulic Limestone—occurring below the level of the subsoil as isolated boulders of greyish-white porcellaneous limestone. Ostracods: *Ektyphocythere triangula, Praeschuleridea subtrigona subtrigona, Cytheropterina comica, Micropneumatocythere globosa, Kirtonella plicata* and *Progonocythere cristata.*		
3. Grey clay. Ostracods: *Kirtonella plicata, Asciocythere lacunosa, Tetracytheridea punctata* and *Eocytheridea lacunosa* . . .	4	0
2. Ironstone-mudstone. Lamellibranchs present throughout. Ostracods: *Progonocythere* cf. *reticulata, Cytheropterina gravis, Praeschuleridea subtrigona subtrigona, P. ventriosa, Asciocythere lacunosa* and *Micropneumatocythere globosa*	2	0
1. Grey calcareous sandstone with shells. Ostracods: *Progonocythere reticulata, Cytheropterina gravis, Praeschuleridea subtrigona subtrigona, P. ventriosa, Asciocythere lacunosa, Eocytheridea lacunosa, E.* ? *erugata, Paracypris bajociana* and *Pneumatocythere bajociana* . . . . . seen to	2	0

Section No. 5. Whitwell Oolite, Seamer Lime and Stone Co. Quarry, Whitwell. Almost complete section through the Whitwell Oolite and the base of the Upper Limestone (Text-fig. 2).

Upper Limestone

19. Yellow sand	1	4
18. Yellow, flaggy sandstone with interbedded sand. . . .	1	7
17. Sandy limestone—almost a calcareous sandstone. Ostracod: *Praeschuleridea subtrigona magna*	1	3
16. Yellow, false-bedded sand with thin lamellae of clay at base . .	4	0
15. Clay	0	5
14. False-bedded, yellow sand	0	10
13. Lens of flaggy sandy limestone. Ostracods: *Southcavea reticulata, Progonocythere cristata* and *Praeschuleridea subtrigona magna* .	1	4
12. False-bedded sand	1	0
11. Alternating bands of white sand and chocolate-brown clay . .	1	5
10. Alternating bands of yellow sand and brown clay . . .	1	5

SOUTH

YONS

NAB

BEDS

MILLEPORE

OOLITE

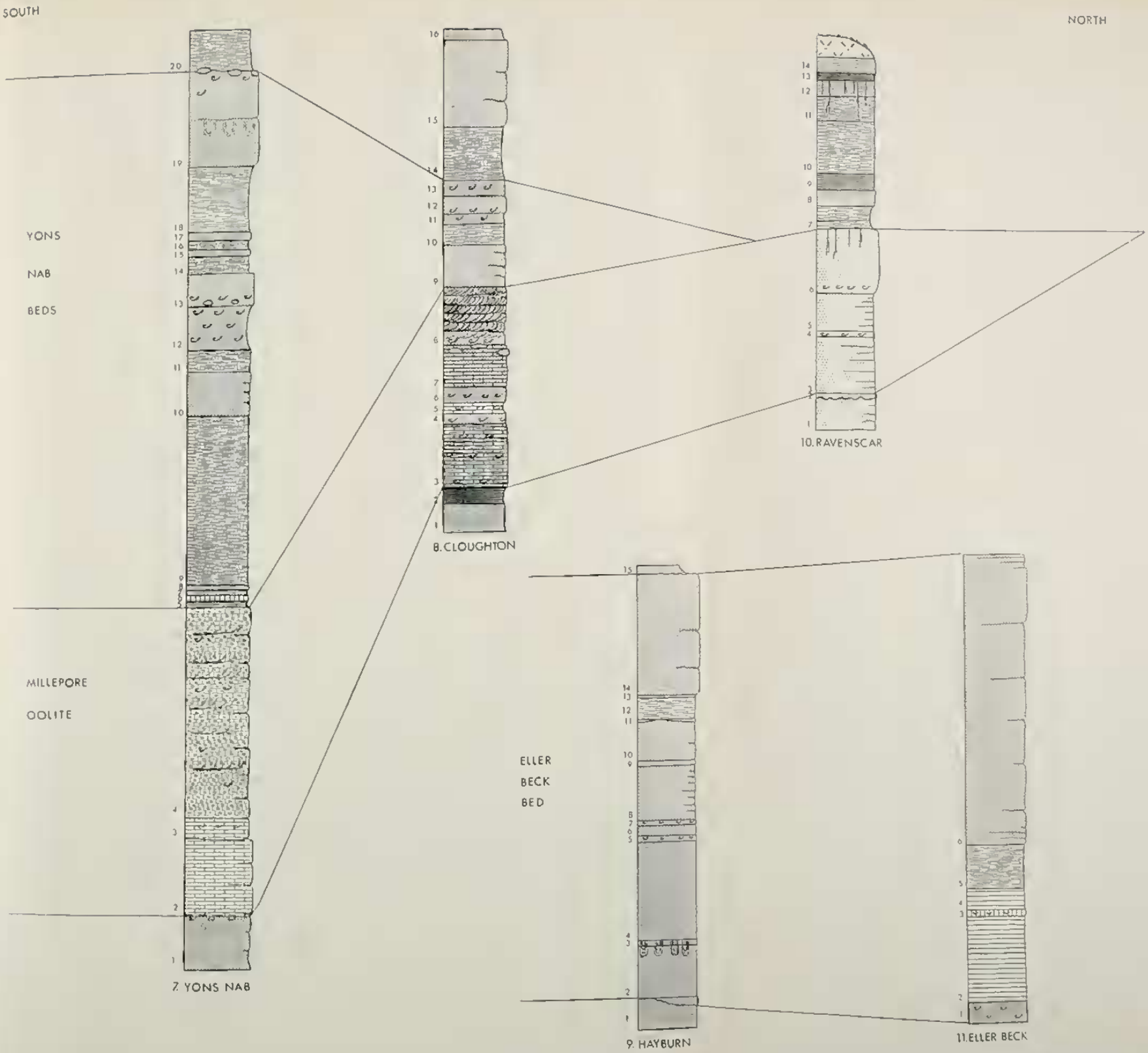


FIG. 3. Sections 7–11.

	ft.	in.
Whitwell Oolite		
9. Flaggy, sandy oolite. Ostracods: *Progonocythere cristata, Praeschuleridea subtrigona magna, Eocytheridea lacunosa* and *Micropneumatocythere globosa*	0	8
8. Purple oolitic clay	0	2
7. Grey oolitic clay. Ostracods: *Praeschuleridea subtrigona magna, Eocytheridea elongata, E. ? erugata, E. ? astricta, Micropneumatocythere globosa* and *Pneumatocythere bajociana*	2	5
6. Flaggy oolite, ironstained in parts. Surface showing ripple markings. Ostracods: *Eocytheridea faveolata* and *Praeschuleridea subtrigona magna*.	0	10
5. White-weathering, soft, coarsely oolitic limestone. Ostracods: *Praeschuleridea subtrigona magna, Dolocythere maculosa, Systenocythere exilofasciata, Kirtonella reticulata, Eocytheridea ? erugata, E. faveolata, E. carinata, Fuhrbergiella (P.) minima, Micropneumatocythere globosa, Monoceratina vulsa* and *Pleurocythere kirtonensis*	6	9
4. Cream weathering, blue hearted oolite. Ostracods: *Kirtonella reticulata, Praeschuleridea subtrigona magna, Eocytheridea ? erugata, E. ? astricta, E. carinata, Micropneumatocythere convexa, M. globosa, Systenocythere exilofasciata, Monoceratina vulsa, Fuhrbergiella (P.) minima, Paracypris bajociana, Aulacocythere punctata, Cytherelloidea catenulata, Ektyphocythere triangula* and *Dolocythere maculosa*	11	0
3. Yellow-brown sandstone. Ostracods: *Praeschuleridea subtrigona magna* and *Micropneumatocythere globosa*	0	7
2. Yellow sand with shells at top	2	0
1. False-bedded, coarsely oolitic limestone. Ostracods: *Progonocythere cristata, Praeschuleridea subtrigona magna, Eocytheridea ? astricta, E. carinata, Fuhrbergiella (P.) minima, Micropneumatocythere globosa* and *Paracypris bajociana* seen to	6	6

Section No. 6. Upper Limestone and Whitwell Oolite exposed at Crambeck. The section through the Upper Limestone is almost complete (Text-fig. 2.).

	ft.	in.
Upper Limestone		
10. Thin, flaggy, oolitic limestone. Ostracods: *Eocytheridea ? erugata, Micropneumatocythere globosa, Praeschuleridea subtrigona magna, Cytheropterina plana* and incertae sedis about	10–12	0
9. Yellow sandstone	1	2
8. Soft yellow sand	2	0

	ft.	in.
7. Flaggy sandy oolite. Ostracods: *Eocytheridea* ? *acuta, Micropneumatocythere globosa, Dolocythere maculosa, Praeschuleridea subtrigona magna, Kirtonella reticulata* and *Pneumatocythere carinata*	1	0
6. Yellow sandstone and unconsolidated sand	9	0

Whitwell Oolite

5. Hard, crystalline limestone	0	7
4. Sandy oolite. Ostracods: *Micropneumatocythere globosa, Praeschuleridea subtrigona magna* and *Systenocythere exilofasciata*	1	3
3. Sandy limestone	1	9
2. Soft yellow sand	0	5
1. Coarse creamy oolite. Ostracods: *Eocytheridea carinata, E.* ? *erugata, Micropneumatocythere globosa, Praeschuleridea subtrigona magna, Dolocythere maculosa, Pneumatocythere carinata* and *Paracypris bajociana* seen to	6	7

Section No. 7. Complete section through the Millepore Oolite and the overlying Yons Nab Beds exposed along the foreshore at Yons Nab headland (Text-fig. 3). For the list of macrofossils obtained from this section see Bate (1959 : 158–9).

20. Grey shale of the Upper Middle Deltaic Series	2	4

Yons Nab Beds

19. Medium-grained grey sandstone, ironstained in the upper 12 inches with ironstone nodules and fossil casts; worm burrows in the lower $3\frac{1}{2}$ feet	4	5
18. Grey sandy shale	3	0
17. Ironstone band	0	3
16. Grey sandy shale	0	5
15. Ironstone band	0	2
14. Sandy shale	0	9
13. Argillaceous sandstone with ironstone nodules at the base. Southwards this bed grades laterally into a sandy limestone. Ostracods: *Progonocythere cristata, Pneumatocythere bajociana, Eocytheridea lacunosa, E. faveolata, E.* ? *astricta, E.* ? *acuta, Micropneumatocythere convexa, Systenocythere exilofasciata, Dolocythere maculosa* and *Praeschuleridea subtrigona magna*	1	6
12. Highly fossiliferous grey shale with white shells. Ostracods: *Progonocythere cristata, Pneumatocythere bajociana, Paracypris bajociana, Micropneumatocythere globosa, Kirtonella plicata* and *Praeschuleridea subtrigona magna*	2	0
11. Sandy, micaceous, grey shale	1	0

	ft.	in.
10. Yellow micaceous sandstone with plant remains and ripple markings	2	1
9. Grey, sandy shale with plant remains	8	0
8. Ironstone band	0	2
7. Grey shale	0	5
6. Mudstone band	0	3
5. Grey shale. Ostracods common: *Cytheropterina plana, Pneumatocythere bajociana, Micropneumatocythere globosa, Paracypris bajociana, Systenocythere exilofasciata, Ektyphocythere triangula, Asciocythere lacunosa, Kirtonella reticulata, Eocytheridea lacunosa. E. ? erugata, E. ? astricta, E. carinata, Dolocythere maculosa, Homocytheridea cylindrica, Praeschuleridea ventriosa* and *P. subtrigona magna*.	0	4

Millepore Oolite

4. Coarse, false-bedded, shelly oolite. Ostracods: *Progonocythere cristata, Pneumatocythere carinata* & *P. bajociana, Micropneumatocythere globosa, Monoceratina* cf. *vulsa, Eocytheridea faveolata, E. ? erugata, E. lacunosa, E. ? astricta, Dolocythere maculosa* and *Praeschuleridea subtrigona magna*	10	0
3. Grey, shelly oolite. Ostracods: *Micropneumatocythere globosa, Paracypris bajociana, Eocytheridea carinata* and *Praeschuleridea subtrigona magna*.	1	0
2. Fine-grained limestone. Ostracods: *Systenocythere exilofasciata, Eocytheridea lacunosa* and *Praeschuleridea subtrigona magna*	3	6

Lower Middle Deltaic Series

1. Yellow sandstone, the top 6 inches containing crinoid ossicles seen to	2	0

Section No. 8. Complete section through the Millepore Oolite and the overlying Yons Nab Beds. Section exposed at Cloughton Wyke, along the foreshore and at the base of the low cliff (Text-fig. 3).

Upper Middle Deltaic Series

16. Sandy shale seen to	1	0
15. Yellow, false-bedded sandstone with plant roots	4	2

Yons Nab Beds

14. Sandy shale, indet. ostracods	2	5
13. Grey-black, ironstained, fossiliferous shale with coal. Lamellibranch casts abundant. Ostracods mainly represented by internal costs: *Praeschuleridea subtrigona magna*	0	9

	ft.	in.
12. Thinly-bedded sandstone with fossil casts and indeterminate ostracods	0	10
11. Grey-black, ironstained shale, very fossiliferous. Lamellibranch and ostracod casts	0	5
10. Sandy shale with thin sandstone bands. Fossil casts and plant remains. Ostracods indeterminate	1	0
9. Flaggy sandstone with plant remains	2	1
Millepore Oolite		
8. Yellow, false-bedded sandstone with fossil casts at the base	2	8
7. Sandy limestone with ironstone nodules in the upper part. Ostracods: *Eocytheridea lacunosa, E.* ? *erugata, E.* ? *acuta, E.* ? *astricta, E. carinata, Micropneumatocythere globosa, Praeschuleridea subtrigona magna, Dolocythere maculosa, Cytheropterina plana, Kirtonella reticulata, Southcavea reticulata, Ektyphocythere triangula* and *Paracypris bajociana*	1	10
6. Fossiliferous mudstone. Ostracods: *Eocytheridea carinata, E.* ? *astricta, Micropneumatocythere convexa, M. globosa, Praeschuleridea subtrigona magna, Fuhrbergiella* (*P.*) *minima* and *Kirtonella reticulata*	0	9
5. Fossiliferous limestone. Ostracods: *Eocytheridea* ? *erugata, E. carinata, E.* ? *astricta, Micropneumatocythere globosa, Praeschuleridea subtrigona magna, Dolocythere maculosa, Fuhrbergiella* (*P.*) *minima, Cytheropterina plana, Kirtonella reticulata* and ?*Homocytheridea cylindrica*	0	6
4. Yellow sandstone with fossil casts	0	7
3. Fine-grained, fossiliferous, calcareous mudstone. Ostracods: *Micropneumatocythere globosa, Eocytheridea* ? *astricta, Praeschuleridea subtrigona magna* and ?*Monoceratina vulsa*	3	0
2. Dark-grey shale. Ostracods as internal casts	0	9
Lower Middle Deltaic Series		
1. Light grey shale.		

Section No. 9. Hayburn, complete section through the Eller Beck Bed (Text-fig. 3).

15. Grey shale of the Lower Middle Deltaic Series.		
Eller Beck Bed		
14. Massive sandstone with ripple markings along bedding planes	5	9
13. Ironstone band	0	2
12. Alternating bands of shale and sandstone	0	11
11. Ironstone band	0	2

		ft.	in.
10.	Sandstone	1	10
9.	Ironstone band	0	3
8.	Flaggy, micaceous sandstone	2	10
7.	Fossiliferous ironstone band	0	3
6.	Sandstone	0	2
5.	Fossiliferous ironstone band	0	3
4.	Dark grey shale	4	8
3.	Ironstone band from which worm burrows of the same composition pass down into the bed below	0	3
2.	Grey shale, with impersistent ironstone at the base	1	0–7

Lower Deltaic Series

1.	Grey shale	seen to	1	0

Section No. 10. Complete section through the Millepore Bed as exposed at the top of the high cliff at Ravenscar (Text-fig. 3).

Upper Middle Deltaic Series

14.	Grey-black shale	seen to	0	11
13.	Coaly shale		0	5
12.	Grey shale with plant roots extending from bed 13		0	8
11.	Sandy shale with plant roots		0	9
10.	Sandy shale		2	5
9.	Ironstained shale		0	9
8.	Yellow sandstone with plant debris		0	9
7.	Grey-black sandy shale, carbonaceous at base		1	2

Millepore Bed

6.	Massive sandstone with upper 2 ft. 6 ins. silver ganister containing vertical plant roots. Lower 11 ins. with lamellibranch casts	3	5
5.	Flaggy, false-bedded sandstone	1	10
4.	Yellow sandstone with fossil casts	0	4
3.	Flaggy, yellow, micaceous sandstone	2	8

Lower Middle Deltaic Series

2.	Band of doggers, weathering hollow		0	3
1.	White, flaggy sandstone	seen to	1	6

Section No. 11. The type section of the Eller Beck Bed, a complete section exposed in the banks of the Eller Beck (Text-fig. 3).

		ft.	in.
	Eller Beck Bed		
6.	Massive, buff-yellow sandstone with ripple markings along some bedding planes	13–14	0
5.	Sandy shale and thin, flaggy sandstone showing false bedding	2	2
4.	Dark-grey ironstained shale	1	0
3.	Fossiliferous ironstone band	0	5
2.	Dark-grey ironstained shale	4	2
1.	Fossiliferous ironstone seen to	1	0

IV CORRELATION

The only definite dating of the Oolites at the present time is the recorded occurrence of ammonites of *discites* age in the Lower Lincolnshire Limestone. Arkell (1933 : 214), however, mentions that *Trigonia hemisphaerica* has been found in the Kirton Marl of Kirton Lindsey and that this lamellibranch is to be found in the Cotswolds only in the Lower Trigonia Grit, a bed also of *discites* age. By inference this would suggest that the Lower Lincolnshire Limestone and the base of the Upper Lincolnshire Limestone belong to the single ammonite zone of *Hyperlioceras discites*. Within the Upper Lincolnshire Limestone the only recorded ammonite is stated to be one of the "*humphriesianus-group*" by Cross (1875 : 121) from the Scunthorpe district. No precise locality was given. Kent (personal communication) states that he has been unable to locate this ammonite and the record could be erroneous. The Grey Limestone Series of Yorkshire which is of *humphriesianum* age, certainly in part, has a very different ostracod fauna from that of the Lincolnshire Limestone and hence no part of the latter can be correlated with beds of that age.

Table 4 indicates a general uniformity throughout the Lincolnshire Limestone and the equivalent beds in Yorkshire. It also shows the restriction of *Cytheropterina comica* and *C. gravis* to the Lower Lincolnshire Limestone and the Hydraulic Limestone–Basement Beds horizon in Yorkshire, and the replacement of these species by *C. plana* in the Millepore and Whitwell Oolites. *C. plana* has not yet been found in the Upper Lincolnshire Limestone. *Tetracytheridea punctata* is restricted to the Basement Beds and the horizon below the Hydraulic Limestone but has not yet been recorded from the Lower Lincolnshire Limestone.

Fuhrbergiella (*Praefuhrbergiella*) *minima* is restricted to the Millepore and Whitwell Oolites. *Praeschuleridea subtrigona subtrigona* is now known to be restricted to the Lincolnshire Limestone and a few beds within the Cave Oolite, and is replaced to the north of Market Weighton by the geographic subspecies *P. subtrigona magna*. *Glyptocythere*, abundant within the Grey Limestone Series, is virtually absent from the Lincolnshire Limestone but occurs within the highest beds of the Upper Lincolnshire Limestone. The species there is similar to *G. costata* Bate (1965 : 106) but is much larger. No specific name can yet be given to this ostracod because of indifferent

Stage	North of Market Weighton	South of Market Weighton	North Lincolnshire
BATHONIAN	Upper Deltaic Series	Upper Estuarine Series	Upper Estuarine Series
	Grey Limestone Series		Unconformity - beds of equivalent age missing
	Upper Middle Deltaic Series		
	Yons Nab Beds/Upper Limestone	Cave Oolite	Hibaldstow Oolite
	Millepore Oolite/Whitwell Oolite		Kirton Shale (Acanthothiris crossi Bed)
BAJOCIAN	Lower Middle Deltaic Series	Basement Beds	Kirton Cementstone Series
	Hydraulic Limestone/Eller Beck Bed	Hydraulic Limestone	Blue & Silver Beds
	Lower Deltaic Series	Lower Estuarine Series	Lower Estuarine Series
	Dogger	No equivalent, Dogger missing	Northampton Sand

TABLE 3. Correlation of Bajocian sediments of Yorkshire and Lincolnshire. It is possible the highest beds of the Upper Lincolnshire Limestone in South Lincolnshire are of the same age as the Upper Middle Deltaic Series. The Grey Limestone Series is not, however, represented in Lincolnshire.

preservation. From the evidence of the ostracod faunas it is possible to suggest a broad correlation of the Yorkshire and Lincolnshire sediments as indicated in Table 3.

Although the ostracod faunas in the Lower Lincolnshire Limestone, Hydraulic Limestone and associated marls and sandstones, and the Basement Beds are broadly uniform with beds higher in the succession the common occurrence of *C. gravis* and *C. comica* and their restriction to this horizon supports previous stratigraphical correlations. A number of ostracod species peculiar to the Basement Beds are considered to be of local significance only. Correlation of the Hydraulic Limestone with the Eller Beck Bed farther north must be considered solely on stratigraphical grounds as there are no ostracods in the latter marine horizon. This northward facies change from a limestone into a sandstone is to be expected on approaching a delta and will be dealt with in the next section.

The Millepore and Whitwell Oolites have *Fuhrbergiella* (*P.*) *minima* as a common ostracod but otherwise the fauna is basically uniform with that in the Upper and Lower Lincolnshire Limestones. *Cytherelloidea eastfieldensis*, found in the Lower Lincolnshire Limestone and in the Basement Beds is neither represented in the Millepore/Whitwell Oolites nor in the Upper Lincolnshire Limestone. The Yorkshire sediments also appear to have a dominant *Eocytheridea* fauna which may be geographically controlled. One species *E.* ?*acuta* is entirely restricted to Yorkshire. The Yons Nab Beds and Upper Limestone have the same ostracods as those appearing in the underlying Oolites and must be part of the same marine transgression.

By inference the major part of the Lincolnshire Limestone probably belongs to the

Hyperlioceras discites Zone, although the highest beds of the Upper Lincolnshire Limestone are possibly slightly younger than this. By correlation the two marine horizons in Yorkshire must also be of *discites* age—this is particularly true for the Hydraulic Limestone/Eller Beck Bed horizon, the marine sediments below, the Basement Beds above and the Lower Middle Deltaic Series. It is less certain how much (if not all) of the Cave, Whitwell and Millepore Oolites may be similarly dated. Certainly there is no evidence in the ostracod fauna to suggest any considerable range in time.

In conclusion, the ostracods, although not giving a very fine correlation between the Yorkshire and Lincolnshire Oolites, substantiate previous stratigraphical correlations. The reason why the ostracods are so uniform throughout the succession is considered to be due to the fact that the Yorkshire and Lincolnshire sediments were deposited during a very short period of time, too short for much evolutionary change to take place. The only apparent evolutionary change appears in the genus *Cytheropterina*. Perhaps one of the more important aspects of the interpretation of the ostracod faunas is to place the topmost beds of the Upper Lincolnshire Limestone below the Grey Limestone Series. Certainly it is doubtful whether the Lincolnshire Limestone as a whole ranges any higher than the *Sonninia sowerbyi* Zone and probably is contained completely within that zone.

APPENDIX

A number of minor sections have been examined which do not appear in the " Stratigraphical Sections " because they are either incomplete or not essential to the stratigraphy of the area. However, a number of ostracod species occur in these minor exposures but not at the same horizon elsewhere. The distribution table (Table 4) would, therefore, be erroneous if they were omitted. A complete faunal list for each of the localities mentioned below is not given, and only those records which extend the stratigraphical range of a species are listed.

1. Upper Limestone—Stonecliff Wood, close to section No. 6, map reference SE/736675 : *Asciocythere acuminata, Eocytheridea* ? *astricta, Eocytheridea faveolata, Systenocythere exilofasciata* and *Systenocythere* ? sp.

2. Millepore Oolite—Osgodby Nab, map reference TA/065855 : *Aulacocythere punctata, Eocytheridea* ? *acuta* and *Eocytheridea reticulata.*

3. Millepore Oolite—Cloughton, map reference TA/021958 : *Cytheropterina plana.*

4. Whitwell Oolite—Bulmer, map reference SE/704678 : *Southcavea grandis.*

5. Kirton Cementstone Series—Kirton Lindsey, map reference SE/942011 : *Pleurocythere kirtonensis.*

V PALAEOGEOGRAPHY

Examination of the ostracod faunas has shown the Lincolnshire Limestone to be of equivalent age to the Yorkshire Oolites and the Hydraulic Limestone/Eller Beck Bed horizon below. Lithologies in some instances remain constant though eventually all become strongly arenaceous and finally completely so when traced northwards.

The environment of deposition of the Lincolnshire Limestone may be treated as a whole. In the Lincoln area the Upper Lincolnshire Limestone is strongly bedded,

OSTRACOD SPECIES	Grey Limestone Series		Basement Beds	Kirton Cementstone Series	Blue and Silver Beds
	polita Zone	*scitula* Zone			
Glyptocythere sp.					
Glyptocythere costata	●				
Glyptocythere polita	●				
Glyptocythere scitula		●			
Malzia bicarinata	●				
Malzia unicarinata	●				
Monoceratina scarburoughensis		●			
Cytonidea faveolata		●			
Cloughtonella rugosa		●			
Fuhrbergiella (Praefuhrbergiella) horrida horrida	●	●			
Progonocythere acuminata	●	●			
Progonocythere yonsnubensis		●			
Pleurocythere sp.		●			
Paracytheridea? cytonensis		●			
Praeschuleridea subtrigona intermedia	●	●			
Ljubimovella piriformis		●			
Mesocytheridea howardianensis		●			
Southcavea microcellulosa		●			
Systenocythere ovata		●			
Eocytherapteron? sp.		●			
Vernoniella bajociana		●			
Vernoniella? cytonensis		●			
Paracypris bajociana		●	●	●	
Cytherella fullonica				●	●
Cytherelloidea catenulata				●	●
Platella jurassica				●	
Bairdia hilda				●	●
Monoceratina vulsa			●	●	
Monoceratina sp. cf. *M. scrobiculata*					
Progonocythere cristata				●	
Acanthocythere (Protoacunthocythere) faveolata			●	●	
Aulacocythere punctata			●	●	
Aulacocythere reticulata					
Fuhrbergiella (Praefuhrbergiella) minima					
Fuhrbergiella (Praefuhrbergiella) arens				●	●
Micropneumatocythere convexa			●	●	
Micropneumatocythere globosa				●	●
Pneumatocythere bajociana			●	●	●
Pneumatocythere carinata				●	
Pleurocythere kirtonensis			●	●	
Pleurocythere nodosa					
Pleurocythere sp.			●		
Dolocythere maculosa			●	●	●
Asciocythere acuminata			●		
Asciocythere lacunosa			●	●	
Eocytheridea? acuta					
Eocytheridea? astricta			●		
Eocytheridea carinata					
Eocytheridea elongata			●		
Eocytheridea? erugata					
Eocytheridea faveolata				●	
Eocytheridea lacunosa			●	●	
Eocytheridea reticulata				●	
Praeschuleridea subtrigona subtrigona				●	●
Praeschuleridea subtrigona magna					
Praeschuleridea ventriosa			●	●	
Cytheropterina camica			●	●	●
Cytheropterina gravis			●	●	●
Cytheropterina plana					
Kirtonella plicata					
Kirtonella reticulata					
Ektyphocythere triangula			●	●	●
Southcavea reticulata				●	
Southcavea bajociana			●		
Southcavea grandis					
Systenocythere exilofasciata			●	●	●
Systenocythere sp.					
Camptocythere lincolnensis				●	●
Cytheromorpha (?) greetwellensis				●	
Cytherelloidea eastfieldensis			●	●	
Progonocythere reticulata			●		
Homocytheridea cylindrica			●		
Tetracytheridea punctata			●		
Paraschuleridea arnata			●		
Paraschuleridea sp.			●		

OSTRACOD SPECIES	Grey Limestone Series: *polita* Zone	Grey Limestone Series: *scitula* Zone	Upper Lincolnshire Limestone South	Yons Nab Beds	Upper Limestone	Millepore Oolite	Whitwell Oolite	Cave Oolite	Kirton Shale	Hydraulic Limestone and associated beds	Basement Beds	Kirton Cementstone Series	Blue and Silver Beds
Glyptocythere sp.	•												
Glyptocythere costata	•												
Glyptocythere polita		•											
Glyptocythere scitula	•												
[illegible]	•												
[illegible]		•											
[illegible]		•											
[illegible]		•											
Cloughtonella rugosa													
Fuhrbergiella (Praefuhrbergiella) horrida	•	•											
horrida	•	•											
Progonocythere [illegible]		•											
Progonocythere [illegible]		•											
Pleurocythere sp.		•											
Praeschuleridea ? [illegible]	•	•											
Praeschuleridea subtrigona intermedia		•											
[illegible] *perforata*		•											
[illegible]		•											
[illegible]		•											
[illegible]		•											
Eocytheropteron ? sp.		•											
Terquemula bajociana		•											
Terquemula ? [illegible]		•	•	•		•	•	•	•	•	•	•	
Paracypris bajociana									•			•	•
Cytherella fullonica			•				•	•	•			•	•
Cytherelloidea catenulata									•			•	
Bairdia juddiana			•					•	•			•	•
Bairdia hilda			•			•	•	•	•		•	•	
[illegible]									•				
[illegible] sp. cf. *M. scrobiculata*				•	•	•	•		•	•		•	
Progonocythere cristata								•	•		•	•	
[illegible]			•			•	•	•	•		•	•	
[illegible] *punctata*									•				
[illegible] *reticulata*						•	•						
Fuhrbergiella (Praefuhrbergiella) [illegible]			•					•	•			•	•
Fuhrbergiella (Praefuhrbergiella) [illegible]				•		•	•	•			•	•	
Micropneumatocythere convexa			•	•	•	•	•	•		•		•	•
Micropneumatocythere globosa				•		•	•			•	•	•	•
Pneumatocythere bajociana					•	•	•	•				•	
Pneumatocythere carinata			•				•		•		•	•	
Pleurocythere kirtonensis								•	•				
Pleurocythere nodosa											•		
Pleurocythere sp.			•	•	•	•	•	•	•		•	•	•
Dolocythere [illegible]					•			•			•		
[illegible]				•				•		•	•	•	
[illegible]				•	•	•							
Eocytheridea ? [illegible]				•	•	•	•	•			•		
Eocytheridea [illegible]			•	•		•	•	•					
Eocytheridea carinata							•	•			•		
Eocytheridea elongata				•	•	•	•			•			
Eocytheridea ? [illegible]				•	•	•	•	•				•	
Eocytheridea faveolata				•		•	•			•	•	•	
Eocytheridea lacunosa						•						•	
Eocytheridea reticulata			•					•	•	•		•	•
Praeschuleridea subtrigona subtrigona				•	•	•	•	•					
Praeschuleridea subtrigona magna				•									
Praeschuleridea ventriosa										•	•	•	
[illegible]										•	•	•	•
[illegible]										•	•	•	•
[illegible] *plana*				•	•	•							
[illegible]				•					•	•			
[illegible] *reticulata*				•	•	•	•						
[illegible]			•	•		•	•	•	•	•	•	•	•
Southcavea [illegible]			•		•	•		•				•	
Southcavea [illegible]								•			•		
Southcavea grandis							•	•					
[illegible]			•	•	•	•	•	•			•	•	•
[illegible] sp.							•						
Camptocythere lincolnensis												•	•
Cytheromorpha (?) [illegible]									•			•	
Cytherelloidea [illegible]											•	•	
Progonocythere reticulata										•	•		
[illegible] *cylindrica*				•							•		
[illegible] *punctata*										•	•		
Praeschuleridea [illegible]											•		
Praeschuleridea sp.											•		

TABLE 4. Distribution Chart of Ostracoda within the Bajocian of N.E. England.

often coarsely oolitic. The base of this division, the *A. crossi* Bed, when traced only a few miles to the north becomes a clay-marl, rich in ostracods. The Lower Lincolnshire Limestone on the other hand is fairly stable in this part of its development as a chalky, only poorly oolitic rock with chalky marl bands in the upper part (Cementstone Series) but becomes more massively-bedded and in part coarsely oolitic towards the base (Blue and Silver Beds). Deposition appears to have taken place in warm waters rich in calcium carbonate probably similar to the type of deposition prevalent at the present time in the Bahamas. Current action is not much in evidence at some horizons, particularly during the deposition of the Kirton Shale and the marl bands of the Cementstone Series, and here it is not unusual to find all growth stages in the development of the ostracod retained in the sediment. Current action almost invariably winnows out the smaller instars. Horizons exhibiting oolith formation have experienced some current action, and rolled gastropods, often coated with calcium carbonate, are not uncommon.

All the lithological units of the Lincolnshire Limestone point to deposition in a warm, shallow sea in which chemical precipitation of calcium carbonate was probably high and current action, when present, resulted in the formation of ooliths, again very much like the present-day Bahamas.

To the north of Lincolnshire a fairly large delta, situated in north-east Yorkshire, was discharging into the sea, but had little effect upon the Lincolnshire Limestone as such. This was almost certainly due to the presence in the region of Market Weighton of a stable land barrier (occasionally covered by shallow water) which effectively cut off the Yorkshire Basin from marine deposition to the south. Correlation of the Lincolnshire Limestone with the marine horizons in Yorkshire suggests that if the sea did not transgress over the Market Weighton stable area, then it must have passed around it to the east, the main body of the sea being situated in a similar position to the present-day North Sea.

The Lincolnshire Limestone is represented by two marine horizons in Yorkshire, and it is proposed to deal with these separately.

Hydraulic Limestone/Eller Beck Bed

From Lincoln northwards there is an increase in the marl facies within the Lower Lincolnshire Limestone so that to the north of the Humber marked changes occur. Here, the Cave Oolite is still an oolitic limestone but the beds beneath are predominantly marls (the Basement Beds) with some rubbly limestone and a thin (2 ft. 6 ins.) grey, porcellaneous limestone termed the Hydraulic Limestone. The Lower Estuarine Series beneath may be marine but is no longer exposed. The Hydraulic Limestone and associated marine beds are the northern equivalent of the Lower Lincolnshire Limestone as correlated on the ostracod faunas. The ostracod population here is complete in all stages from juvenile instars to adult carapaces, indicative that deposition during Basement Beds time proceeded in relatively quiet waters with little or no current action.

The Hydraulic Limestone does not appear to have passed over the land barrier north of Market Weighton although this area might well have been submerged under